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The Impact of Strategy Funds on Biotechnology in the Mineral and Energy Sectors (1983-1989)

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Project 30.46.03

Biotechnology

MINERAL SCIENCES LABORATORIES

DIVISION REPORT MSL 88-9(CF)

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Introduction

In 1983, the Ministry of State for Science and Technology (MOSST) announced a National Biotechnology Strategy to strengthen the federal capacity in this field. The Department of Energy, Mines and Resources proposed that it form a research network on mineral leaching and metal recovery. The inaugural meeting of the BIOMINET Network was held on October 13 - 14, 1983. Forty-three people attended, (49% from industry and 17% each from government, universities and provincial research organizations). A survey following this meeting indicated that industry was in no position, due to low metal prices, to support what they considered "high risk" research. They felt that biotechnology only had a 50% chance of success in the mineral industry. In December, 1988 the BIOMINET Network has 496 members and more than 55% of them are from the mineral or energy industrial sector.

Bioleaching, Biotechnology, Effluent Treatment, Biofouling
Economic Impact

Introduction

En 1983 , le Ministère d'État de la Science et de la Technologie a annoncé la mise en place d'une stratégie nationale visant à renforcer la compétence des organismes fédéraux en matière de biotechnologie. Le Ministère d'Énergie, Mines et Ressources a proposé la formation d'un réseau regroupant des organismes de recherche interessés par la lixiviation et la récupération des métaux. La réunion d'inauguration du réseau de BIOMINET a eu lieu les 13 et 14 octobre 1983. Quarante-trois personnes étaient présentes (49% d'entre elles provenait du secteur industriel alors que le gouvernement fédéral, les universités et les organismes provinciaux de recherche comptaient chacun pour 17% des personnes présentes). Un sondage effectué après cette réunion a indiqué que, comme les métaux se vendaient à bas prix, le secteur industriel n'avait pas les moyens d'entreprendre des projets de recherche dits "à risque". Ce secteur considérait que dans le domaine des mines la biotechnologie avait seulement 50% de chance de réussite. En décembre 1988, le réseau de BIOMINET est composé de 496 membres dont plus de 55% provient du secteur industriel de l'énergie ou des mines.

biolixiviation, biotechnologie, traitement d'effluents, biosalissure, impact économique

Commercial Successes in Biotechnology

1. In 1984, Denison Mines, with support from CANMET, negotiated a cost-shared agreement under the NRC Biotechnology IRAP program to develop a bioleaching process to commercial scale for the recovery of uranium.

CANMET has been investigating the various parameters for successful bacterial leaching since 1964, and had large scale experience in leaching from their association with Agnew Lake Mines in the mid 1970's. All the accumulated data on bacterial leaching was made available to Denison Mines.

Over the two and one half year process development phase Denison Mines spent in excess of four million dollars and received $2 million from the NRC-IRAP program. The process has now developed to such an extent that in 1987 Denison Mines produce 840,000 lbs of uranium by bacterial leaching and are forecasting about 1,000,000 lbs production in 1988. To meet these production levels, Denison spends in excess of $10 million per annum in capital costs for pipes, bulk-head construction, fans and other equipment for the process.

2. In the summer of 1985, Quebec Cartier Mines approached CANMET for assistance in determining the cause of deposition of a material in their spiral concentrators which was resulting in substantial losses of their iron ore. After unsuccessful investigations of the conventional mineral processing parameters, the biotechnology section of CANMET conducted a microbiological investigation at 18 different points in QCM circuit. This investigation proved that sewage from their sewage treatment lagoon was migrating into the lake 25m from their process water pumping station.

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Thus sewage was being circulated through their circuit, providing nutrients for the bacteria which in turn produced polysaccharide capsular material which was trapping the fine iron ore. This mixture compacted on the surface of the spirals, thereby altering their configuration and reducing the iron ore recovery.

The company has diverted their sewage effluent away from the lake. This has reduced spiral cleaning and maintenance from bimonthly to once annually. The reduction in the biofouling of the spirals in combination with other circuit changes has resulted in QCM achieving their highest recoveries ever. Although no numerical percentage of increase can be attributed to the resolution of the biofouling problem, the company states each 0.1% increase in recovery results in $100,000 p.a. of revenue. Indications are that a 4% increase in recovery was achieved this year.

3. CANMET developed a bioreduction process for the recovery of elemental selenium from mine/mill effluents. In 1987 a pilot plant study was conducted by CMS Rotodisk and the Ontario Research Foundation with financial support from the NRC-IRAP program. In 1988, Kidd Creek Mines initiated a pilot-plant study in late fall but suspended the study due to inclement weather and problems within their mill circuit.
This project will be re-activated in the spring of 1989. If it is successful and implemented at fullscale the process will not only rectify an environmental problem but will also provide $800,000 p.a. in revenue from a new by-product for the company.

4. A major mining company is currently supporting a M.Sc. student from Carleton University to work at CANMET to develop a biological process to degrade a pollutant which is produced during their mineral extraction process.

The process has been developed and pilot-tested in CANMET for the past year. The company intends to set up a larger scale pilot-plant at their refinery in the spring of 1989. A full scale plant is estimated to cost $500,000 and have an annual operating cost of $90,000. Alternative means of treating the pollutant are estimated to cost at least $300,000 p.a.

5. For the past two and one half years the Head of the Biotechnology Section, CANMET has served on an Interdepartmental Technical Committee to advise Transport Canada on economical means to control acid drainage from the pyritic slates on which the airport at Halifax was built. The main acid producer was 225,000 m^3 of waste slate excavated during runway and taxiway construction which had been stock-piled on a 7 hectare site at the airport. CANMET recommended recontouring the pile to optimize runoff then capping the pile with a 15 mm layer of road salt (NaCl) and two 350 mm layers of compacted clay. A 150 mm layer of topsoil was then sodded or hydroseeded to provide a grass cover. The capping was completed in July, 1988 and there has been an 80% reduction in seepage from the pile as well as an 80% reduction in acidity and -60-70% reduction in the iron and aluminum content of the seepage. Hydrated lime consumption in the water treatment plant has been reduced -70% for an annual savings of $360,000.

The CANMET Biotechnology Section has filed four separate patent applications in co-operation with industrial clients or contractors. To date none of the patent application file numbers are available.

Catalytic Effects:

Due to the aforementioned successes, several companies have developed biotechnology research groups or are seriously investigating potential biotechnological solutions to their mineral or energy processing problems.

Table I

Companies which have developed biotechnology research groups

Company	Locations
Nova-Husky Research	Calgary, Alberta
ALCAN International	Jonquière, Quebec
ORTECH International	Mississauga, Ontario
Coastech Research	Vancouver, B.C.
Boojum Research	Toronto, Ontario
P. Lane & Associates	Halifax, N.S.

Table II

Mining or Oil
Companies conducting biotechnological research

Company	Area of Research
ALCAN	Degradation of PAH's
Inco	Leaching of refractory gold ore
Falconbridge	Acid mine drainage
Noranda	Acid mine drainage
HBM&S	Bacterial leaching of Cu & Zn
Husky-Nova	Microbial plugging Bacterial corrosion
Esso	Bacterial corrosion

Through the networking efforts of BIOMINET many liaisons between university researchers and industry have been achieved over the past five years.

Table III
University involvement in biotechnology research with industry

University	Industrial Client	Area of Research
Dalhousie	Denison Mines	Nutrient optimization for leaching
Laurentian	Denison Mines	Psychrophilic strains of T.f. & Fungicides
Waterloo	Denison Mines	Computer Modeling of leaching process
Manitoba	HBM&S	Bacterial leaching of Cu & Zn
Calgary	Various Oil Companies	Bacterial corrosion Microbial plugging
Alberta	Oil Companies	Biodegradation of oil
McMaster	ORTECH, ADM & Denison	Bioadsorbants
UBC	NSERC	Genetics and role of fimbriae in Thiobacilli
Carleton	ALCAN	Biodegradation of a pollutant
Carleton	Transport Canada	Mitigation of Acid Drainage

Also, through BIOMINET various research consortia involving universities, PRO's, Consultants and Industry have evolved for specific research projects.

Table IV
Research consortia in biotechnology

Consortia	Research Project
UBC and Gormely Engineering	Genetics of Thiobacilli
McMaster, ORTECH, Acres, Davy McKee and Denison Mines	Bioadsorbants for uranium
Boojum, Denison & Rio Algom	Chara process
Boojum and Inco	Ecological Engineering Acid Mine Drainage
U. of Manitoba, CANMET & HBM&S	Leaching of Cu & Zn
ORTECH & McMaster	Bioadsorbants
NIOBEC Mines, McGill & CANMET	Degradation of organics in recycle water
Carleton, CANMET and ALCAN	Degradation of a pollutant
Waterloo & Senes Consultants	Bioadsorbants
ORTECH & ALCAN	Humate degradation

Leverage of Other Funds:

With sponsorship from CANMET, BIOMINET members have received $2,083,650 from the NRC-IRAP program in Biotechnology and have successfully completed the three projects.

Table V

NRC-IRAP Contributions to BIOMINET Members

Company	Funding	Project
Denison Mines	$2,000,000	Bioleaching of uranium
CMS-Rotodisk	47,150	Biorecovery of Selenium
Boojum Research	36,500	Chara process

As a result of dissemination of research results and the personal contacts between industrial personnel and researchers at the BIOMINET Annual Meetings or information seminars, industrial support for specific research projects has increased substantially in the past few years.

Table VI
Industrial biotechnological research support in 1988

Research Group	Industrial Client	Funding
Boojum Research	Various Mining Companies	$250,000
Gemini Research	CBDC	50,000
Engenics Inc.	Noranda	40,000
Nova-Husky	"In-house" research and service contracts	500,000
Kidd Creek	Se biorecovery pilot-plant	60,000
ORTECH Int'l	"In-house" research	80,000
Sheritt-Gordon	"In-house" research	150,000
Carleton University	ALCAN	70,000
University of Manitoba	HBM&S	60,000

Under the Manitoba Mineral Development agreement, the Province of Manitoba has spent or committed $235,000 to assist Hudson Bay Mining and Smelting (HBM&S) and the University of Manitoba develop an in-situ bacterial leaching process for the recovery of Cu and Zn from mine wastes left underground in their Flin Flon Mine. HBM&S anticipates recovering about 65% of the metal values left underground over a ten year period. This would result in net revenues of about $20,000,000 for a capital investment of $1,000,000.

Due to the success of the biotechnology program within CANMET, assisted by contract research by BIOMINET members, CANMET has received and responded to numerous cost recovery projects.

Table VII

CANMET Cost Recovery Projects in Biotechnology for 1988/89

Client	Project	Cost
Transport Canada	Biodegradation of de-icing fluids	30,000
Transport Canada	Mitigation of Acid Drainage	13,000
QCM	Microbial Analysis of mill circuit	5,000
Noranda Research	Appraisal of a consultant's report and discussions on acid mine drainage	3,300
NIOBEC*	Degradation of organics in recycle water	39,000
Lenore Exploration*	Bio-oxidation of refractory ores	10-15,000

*These cost recovery projects are currently being negotiated.

Interactions with other Agencies:

CANMET has numerous interactions in biotechnology with other Canadian government departments as well as with specific research groups or foreign government agencies.

Through the Interdepartmental Technical Committee at the Halifax Airport CANMET has interacted with Transport Canada, Department of Public Works, Department of Environment, Fisheries and Oceans and the Nova Scotia Department of Environment.

CANMET has also signed agreements for exchange of information or cooperative research with the U.S. Bureau of Mines, the West German Department of Geosciences and with the European Economic Community.

CANMET has worked closely with NRC-IRAP as scientific authority on the three IRAP projects and holds semi-annual meetings with the Department of Environment, Mining Division to exchange information on the investigation of environmental problems associated with mining.

BIOMINET has sponsored and financially supported Biotechnology Symposia during the Annual Meetings for the Canadian Society of Microbiologists and the Hydrometallurgical Society meetings of the Canadian Institute of Mining. BIOMINET has also participated in the National Convention of the Water Resources Association.

The Biotechnology Section of CANMET has also participated in biotechnology seminars sponsored by Falconbridge Mines Ltd., the Quebec Mining Association, and held biotechnology information sessions at the ALCAN Jonquière laboratory and at ALCAN Corporate Headquarters in Montreal.

Because of its apparent leadership in the commercial application of biotechnology in the Mineral Industry, CANMET in co-operation with the U.S. Bureau of Mines and the U.S. Department of Energy were asked to organize and sponsor the 8th International Symposium on Biohydrometallurgy in Jackson Hole, Wyoming, August 13 - 18th, 1989.

CANMET currently has a post-doctoral fellow from Rhône Poulenc Inc., France, for training in the bioadsorption of metals from dilute solution. All expenses incurred for this post-doctoral fellow are being paid by Rhône-Poulenc Inc.

Interactions with Universities:

CANMET has not only acted as a liaison between the BIOMINET University members and industry in establishing joint or co-operative projects as outlined in Tables III and IV, but has been actively involved in presenting seminars on biotechnological applications to mining at various universities. CANMET personnel have presented such seminars at Carleton University, The University of Lethbridge, the University of New York, Syracuse, Ohio State University and the University of Calgary.

CANMET currently has an M.Sc. and Ph.D. student conducting their thesis work within the CANMET laboratories. The M.Sc. student is supported by ALCAN International Ltd. and the Ph.D. student is an employee of CANMET but her research is being partly supported by Transport Canada.

With co-operation of the Biological Sciences Departments of various universities CANMET has been able to sponsor and conduct three two day workshops entitled "Basic Microbiology for the Mineral or Fossil Fuel Industries".

Over the past three years about 75 industrial members of BIOMINET have participated in these workshops and have responded stating that the workshops were informative and useful. Further, BIOMINET sponsored a one-day workshop to explain the various government support programs for biotechnology research or commercial application that are available for industry.

Interactions with Centres of Excellence:

The Biotechnology Section of CANMET has been asked to participate in the Microbial Ecology Centre of Excellence which will be lead by Dr. J.W. Costerton, The University of Calgary. CANMET will form one of the research nodes responsible for research on fixed bacterial films for the treatment of mining or fossil fuel effluents which impact on the environment. Research may also evolve into the role and treatment of microbial biofilms in metal corrosion and the biofouling of industrial process streams. Through the BIOMINET Network research results or process developments can be transferred quickly and effectively to the mineral and fossil fuel industries.

Funding for Biotechnology in the Mineral and Fossil Fuel Industries:

The departmental "A base" funding for the Biotechnology Section is presented in Table VIII.

In addition to the "A-base" funding CANMET has received the following funding from MOSST for the period 1983-89.

Table VIII

Biotechnology "A" base Expenditure

Mineral Sciences Laboratories 83/84 to 88/89

$ in thousands

(py in brackets)

	83/84	84/85	85/86	86/87	87/88	88/89	**Total**
Leaching	80	120	135	155	100	92	682
	(1.6)	(2.2)	(2.4)	(2.6)	(1.6)	(1.4)	(11.8)
Sorption	35	35	39	60	63	53	285
	(0.7)	(0.7)	(0.7)	(1.0)	(1.0)	(0.8)	(4.9)
Destruction	-	-	12	24	25	26	87
			(0.2)	(0.4)	(0.4)	(0.4)	(1.4)
Environmental	135	180	145	115	189	284	1048
	(2.7)	(3.4)	(2.6)	(1.9)	(3.0)	(4.3)	(17.9)
Network	35	35	34	34	38	40	216
	(0.7)	(0.7)	(0.6)	(0.6)	(0.6)	(0.6)	(3.8)
Total	$285	$370	$365	$388	$415	$495	$2318
	(5.7)	(7.0)	(6.5)	(6.5)	(6.6)	(7.5)	(39.8)

Table IX

Strategic Funding for Biotechnology to CANMET

Year	Contract Funds	Network Funds
1983/84	250,000	25,000
1984/85	250,000	25,000
1985/86	250,000	25,000
1986/87	250,000	25,000
1987/88	250,000	25,000
1988/89	305,000	25,000

Conclusions:

From the aforementioned liaison activities and the recent financial support of biotechnological research by the Mineral and Fossil Fuel Sectors it appears that the National Biotechnology Strategy has been very effective in promoting the application of biotechnology in these resource sectors and that industry now recognizes the potential of this technology and is gradually investing more and more money into this area of research and process development.

Future Development of Biotechnology in the Mineral and Fossil Fuel Sectors

Over the past five years CANMET and BIOMINET have proven the potential of biotechnology in the areas of metal extraction and mitigation of environmental problems arising from the mineral processing. Strategic funding for the Mineral Sector should be maintained at its present level in order sustain the ongoing biotechnological process development in this sector.

At the annual BIOMINET meeting in Calgary, November 2-4, 1988 the technical session covered the research currently underway in the coal and petroleum industry. Representatives from the major oil companies were in attendance and indicated that most companies are closely monitoring biotechnology developments, but at present, only two or three companies are directly involved in biotechnology research. They also had not been aware of BIOMINET but felt that BIOMINET could and should act as a focal point for the development of a biotechnology research program in fossil fuels.

Thus, CANMET proposes that the current funding of the BIOMINET Network be increased to $830,000 p.a.; this funding would be subdivided as follows:

Contracts in Mineral Processing	305 K
Contracts in Fossil Fuel Processing	500 K
Networking	25 K

For fiscal 88/89 CANMET Mineral Science Lab., has contracted out $110,800 for five diverse research projects encompassing biotechnological techniques or concepts that have application to processing problems in the fossil fuel sector. From discussions with research personnel from the fossil fuel sector, the consensus was that $500,000 p.a. would provide a catalyst to examine various biotechnological approaches to known or anticipated problems in fossil fuel processing.